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# ADDRESS

## *Delivered by the President on Presenting the Gold Medal of the Society to Professor Axel Möller.*

GENTLEMEN,—

It now becomes my duty to put before you the main points in the investigations of Professor Axel Möller on the motion of Faye's Comet, for which your Council have this year awarded him the Gold Medal of the Society, and this I shall endeavour to do in as succinct a manner as possible.

The comet which forms the subject of the investigations for which the Medal has been awarded was discovered by M. Faye at the Observatory of Paris on November 22, 1843, about five weeks after its perihelion passage. Notwithstanding this, the impossibility of representing its motion by parabolic elements was soon evident, and the limited extent of the orbit being indicated a few weeks after discovery, the attention of observers was specially directed to the comet, and observations were made as late as April 10, 1844, by M. O. Struve with the Pulkowa refractor. A pretty complete determination of the orbit from the observations of 1843–44 was made by Le Verrier, who also calculated the perturbations during the ensuing revolution due to the action of *Venus*, the Earth, *Mars*, *Jupiter*, and *Saturn*, and thus obtained the elements corresponding to the next perihelion passage on April 3, 1851. At that time Professor Challis was giving close attention to the observation of comets by means of the Northumberland Equatoreal at Cambridge, and with the aid of the Ephemeris founded upon Le Verrier's elements he succeeded in observing Faye's Comet as early as November 28, 1850, continuing his observations until March 4, or nearly a month after it was seen elsewhere. Observations at this second appearance were confined to the Cambridge Observatory, and the Observatories at Pulkowa, and Harvard College, U.S. Le Verrier issued an Ephemeris corrected by the earlier observations at Cambridge, but did not further continue his calculations.

It does not appear that any computations bearing upon the return of the comet in 1858 were made, beyond an approximate Ephemeris circulated from the *Nautical Almanac* office. With the aid of this Ephemeris the comet was detected by Dr. Bruhns with the Berlin Refractor on September 7, and observations were continued till October 16.

Early in 1859 the Society of Natural Sciences at Dantzic

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offered a prize for the determination of the orbit of Faye's Comet from the three appearances of 1843–44, 1850–51, and 1858, the memoirs to be sent in at the beginning of January, 1861. I am not aware if it was this circumstance which directed Professor Möller's attention to the comet, but it was at this period that his investigation of its motion was commenced. His first paper appeared in No. 1259 of the *Astronomische Nachrichten*, and is dated from Lund in April 1860. Adopting the elements which Le Verrier had brought forward to 1851, he compares them with the series of Cambridge observations, commencing on December 25, 1850, and forming normal places, he obtains corrected elements for 1843. From this amended orbit he calculates the perturbations of *Venus*, the Earth, *Mars*, *Jupiter*, *Saturn*, and *Uranus*, for the intervals over which the comet was observed in 1843–44 and 1850–51, and then makes a comparison with the observations at both appearances. Normal places are again formed and the orbit is further corrected. Thus pretty accurate elements are derived for 1843 November 9, and 1851 February 20, which form the definite results of Professor Möller's first communication.

In No. 1295 of the same periodical he brings the observations made in 1858 to bear upon the orbit, having first calculated the perturbations during the comet's visibility as before, and introduces Encke's hypothesis of a resisting medium, the existence of which had been rendered so probable from the researches made by that astronomer on the motion of the comet which bears his name. He considered that the calculations detailed in this second memoir (involving, it will be seen, three appearances of the comet) proved that an hypothesis was needed to explain the motion of Faye's Comet, and that one of the character advocated by Encke would be nearly correct. This conclusion naturally attracted the attention of astronomers, because Faye's Comet at no time approaches the Sun within the Earth's mean distance, and the effect of a resisting medium could hardly have been expected to have been appreciable upon the comet's motion. This question is further examined by Professor Möller in No. 1314 of the *Astronomische Nachrichten*, with reference to a communication made by Baron Plana to the Turin Academy, and again in No. 1317, with respect to the hypothesis of Valz on the density of the ether.

In No. 1358, Professor Möller has some further researches on the orbit of the comet from the observations at the first three returns, in which additional refinement is introduced in the computation of the planetary perturbations, and a close representation of the observations is produced, the orbit for 1858 being considered not only exact enough for prediction at the ensuing return to perihelion, but for connecting with accuracy the observations that might be then made, with the earlier ones. In his next communication to the *Astronomische Nachrichten*, with reference to Faye's Comet (No. 1522), he made an announcement

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which is of especial interest, as according with the preconceived ideas of astronomers on the improbability of resistance to the motion of the comet from the etherial medium: he there states distinctly that he had given up the idea of action from this cause, and had satisfied himself that the observations at the first three appearances were perfectly accordant, without any hypothesis whatever. This conclusion, it must be observed, had not been arrived at without the introduction of one refinement after another, and wading through a very heavy mass of computations of a difficult and laborious character. In the same memoir, slight corrections are again applied to the elements in 1843–44, 1850–51, and 1858, and the orbit of the latter year is carried forward to the ensuing return in the autumn of 1865, by the calculation of the planetary perturbations in the interval; Professor Möller also supplied an accurate Ephemeris from July 1 to November 22. This memoir, in which precise prediction of Faye's Comet was first made, is dated from Lund, in March 1865. The comet was detected by D'Arrest, with the Copenhagen Refractor, on August 22, and, in publishing his first observation, he wrote, "The agreement with Professor Möller's calculations, after the seven years' invisibility of the comet, is extraordinary, in fact almost complete," the difference being only $1^{s}\cdot7$ in Right Ascension and $4''$ in Declination: notwithstanding the refinement introduced into Professor Möller's work, probably no one had anticipated so admirable a confirmation of the skill and labour with which it had been conducted. In the *Astronomische Nachrichten*, No. 1548, Professor Möller continued his accurate Ephemeris to April 14, 1866.

Resuming his investigations in 1870, he found that when the observations of 1865–66 were brought to bear upon them, in addition to those at the three previous returns, the agreement between calculation and observation was not so satisfactory as before. He accordingly did not shrink from a complete revision of the computation of perturbations, aiming at the utmost attainable accuracy: the normal positions were thoroughly examined, improved places of some of the comparison stars introduced, and, in treating the equations of condition, a term was included for the correction of the mass of *Jupiter* deduced by Bessel from the elongations of his satellites, which had been adopted through the whole of Professor Möller's work. Thus the most precise orbit it was possible to determine for 1865, as the ground-work for further computation, was obtained. The value of *Jupiter's* mass indicated by these laborious researches on the motion of Faye's Comet was found to be $\frac{1}{1047\cdot788}$, that assigned by Bessel being $\frac{1}{1047\cdot879}$, these values agreeing within their probable errors. Details of these additional computations will be found in *V. J. S.*, vol. vii.

The perturbations during the ensuing revolution were calcu-

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lated with all strictness, and elements assigned for the epoch of the comet's return to perihelion in 1873. Its track in the heavens in that year was unfavourable for observation, and only four positions were secured between September 3 and December 23. By the Marseilles observation on the former date, Professor Möller's predicted place was less than six seconds of arc from the true one, a really marvellous confirmation of the accuracy with which his investigations of the comet's motion during forty years had been conducted.

Once more he determined the effect of perturbation during a whole revolution, with the same refinement as previously, and in September 1878 communicated to the Academy of Sciences at Stockholm elements and an accurate Ephemeris for the actual appearance of 1880–81, and, as we have just seen, with renewed success, though the effect of planetary attraction in this interval has been greater than in any other revolution since the comet was discovered.

Not content with following the comet through each successive revolution from 1843, Professor Möller, in a paper presented to the Academy of Stockholm in January 1873, computes the perturbations backward to December 25, 1838, and ascertains the effect of a pretty near approach to *Jupiter* in March 1841, when the distance of the comet from the planet was less than two-thirds of the Earth's mean distance from the Sun: thus the perturbations have been rigorously calculated by Professor Möller from December 25, 1838, to January 13, 1881. In the same paper he also examines the circumstances of a much nearer approach near the passage of the ascending-node in 1816, and infers a minimum distance of about 0·3.

It is necessary to bear in mind that the class of computation involved in Professor Axel Möller's investigations is, so to say, of a high order, and does not admit, as is often the case with heavy masses of astronomical calculations, of being set out for the ordinary computer. Considerable mathematical knowledge, and knowledge of refined methods, and of their adaptability to particular cases is absolutely essential; and Professor Möller's success has proved that he possesses this knowledge in an eminent degree. I believe that you will consider that your Council has been fully justified in awarding to Professor Möller the highest mark of approval and respect which the Royal Astronomical Society has it in its power to bestow, and I further entertain the belief that this award will give satisfaction to astronomers in all countries, as encouraging a very monotonous and tedious, but not less important, branch of astronomical research.

The President then, delivering the Medal to the Foreign Secretary, the Earl of Crawford and Balcarres, addressed him in the following terms:—

In transmitting our Gold Medal to Professor Axel Möller, I ask you, my Lord Crawford, to assure him of the great interest

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which the Royal Astronomical Society has taken in his researches on the motion of Faye's Comet during the long period over which they have extended, and to convey to him the best wishes of the Society that health and energy may be spared him to continue these researches, which have been attended with such admirable and well-merited success.